Week 12

PHY 106 Quantum Physics
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5) Current Research Frontier

5.1) Quantum versus Classical Physics

We had seen that classical physics arises from quantum physics in the limit where "quantisation is too fine to be noticed".

This is called the **correspondence principle** see e.g. sections and 3.1.9) and 3.3.5)

Quantum versus Classical Physics

Nonetheless they are often conceptually very different and there are features that only occur in one or the other.

Classical	Quantum
Well defined	Uncertain
Fundamentally deterministic	Fundamentally probabilistic
Things are in a definite state	Superposition principle, things can be in two states at once

Quantum versus Classical Physics

Classical	Quantum
U(x)>E region is classically forbidden	Tunnel effect, particles can penetrate through U(x)>E region.
Probabilities may add up. No interference for particles	Wave interference effects

Quantum versus Classical Physics

The usual distinction, coming from the smallness of Planck's constant, is this:

Appears classical	Appears quantum
House	Electron
Atom	Photon
Student	Neutrino
Bullet	Atom
Airplane	
(macroscopic)	(microscopic)

However there is no real distinction here, they all should be described by Schrödinger's equation…

5.2) Quantum classical transition

There are **open puzzles** to the question, “why does the world around us look classical, exemplified by:

Example: Schrödingers cat thought experiment

Radioactive sample (see, alpha-decay Example I, 3.3.2)

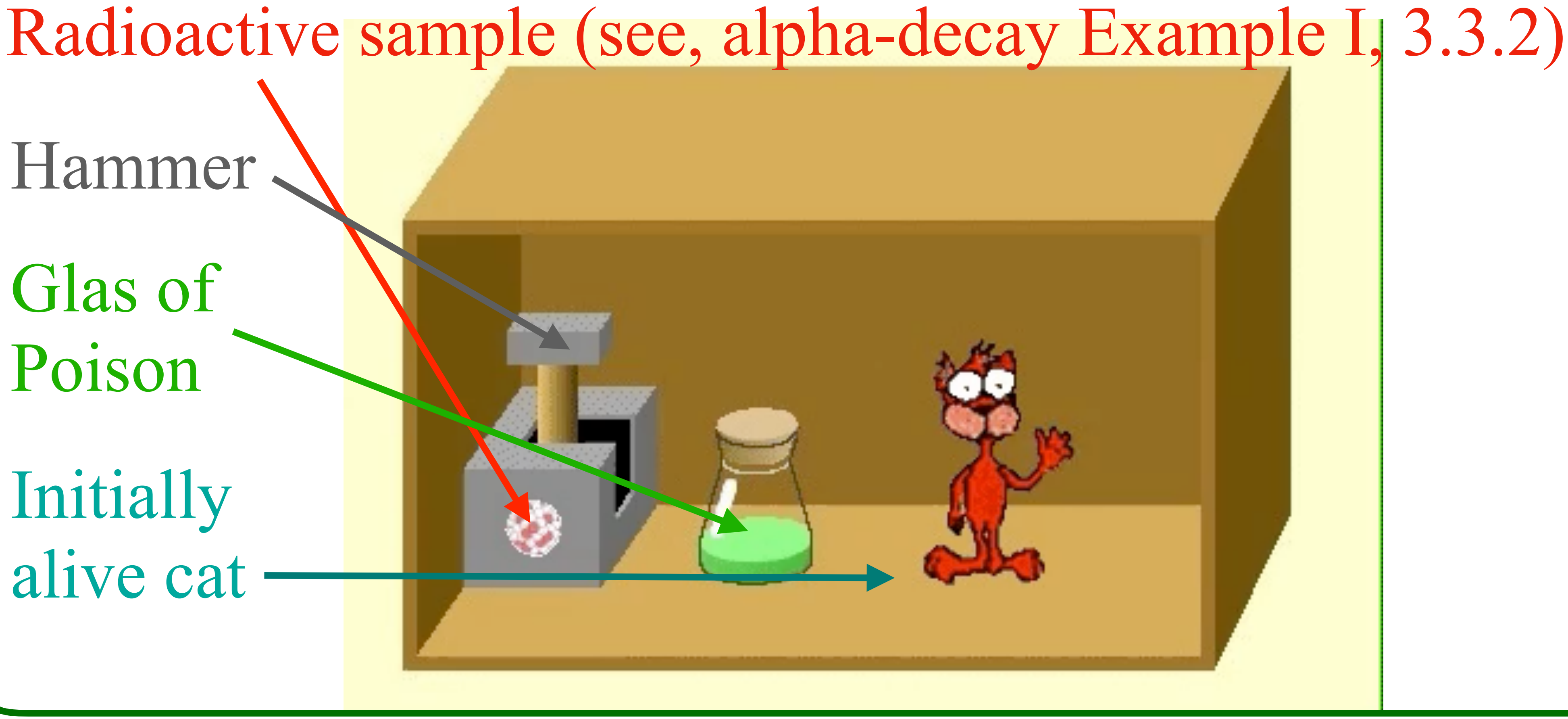
Hammer

Glas of Poison

Initially alive cat

Example: Schrödingers cat thought experiment

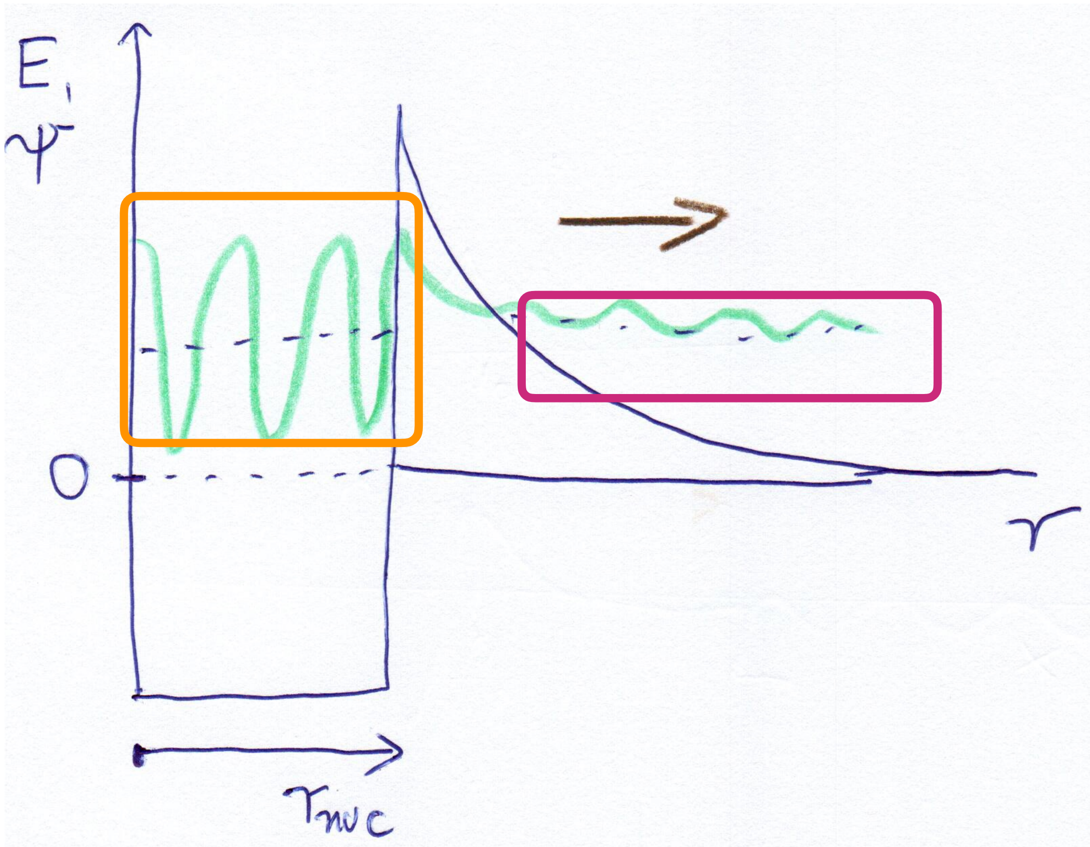
Now suppose we initially close the box, so we **no longer know** (measure) what is happening…



Example: Schrödingers cat thought experiment

After some time, decaying nucleus
is in a **superposition state….**

$$\Psi_{nucleus} = \sqrt{1-\epsilon}\,\phi_{not-decayed} + \sqrt{\epsilon}\,\phi_{decayed}$$



Example: Schrödingers cat thought experiment

If we attempt to quantum mechanically describe **everything** (nucleus, hammer, glass, cat) we then get:

$$\Psi_{nucleus} = \sqrt{1-\epsilon}\,\underline{\phi_{not-decayed}}\,\underline{\phi_{not-fallen}}\,\underline{\phi_{not-broken}}\,\underline{\phi_{alive}}$$

nucleus **hammer** **poison** **cat**

$$+\sqrt{\epsilon}\,\underline{\phi_{decayed}}\,\underline{\phi_{fallen}}\,\underline{\phi_{broken}}\,\underline{\phi_{dead}}$$

This is since:
(i) Many body quantum wavefunction is product of individual pieces (see section 4.1.)
(ii) Schrödingers equation is **linear**

Example: Schrödingers cat thought experiment

It appears the cat is in a superposition state, in which it is **alive and dead at the same time**.

$$\Psi_{nucleus} = \sqrt{1-\epsilon}\,\phi_{not-decayed}\phi_{not-fallen}\phi_{not-broken}\phi_{alive}$$

nucleus **hammer** **poison** **cat**

$$+\sqrt{\epsilon}\,\phi_{decayed}\phi_{fallen}\phi_{broken}\phi_{dead}$$

This is of course rather irritating. Quote from week 0 movies: "When we try to understand quantum physics further, it goes from confusing, to oughtright insane"

Example: Schrödingers cat thought experiment

It **still** (1920-> 2020) the answer of many-body quantum physics that the cat should be both at once until we look into the box.

What selects **alive** or **dead,** when we open the box is fully unclear.